Transgenics for a Better Tomato

Centuries ago when farmers planted and harvested their crops, they knew little about the science involved. Nor did they have a large seed stock. But today, science is helping farmers improve their seed selection. As a result, consumers have access to a wide variety of safe, plentiful, and nutritious foods. In the future, new biotechnology tools like genetic engineering can help plant breeders continue this trend.

Scientists like ARS plant physiologist Autar K. Mattoo know the powerful contributions that science and technology can make to the world's food supply. "Our goal is to develop plants for improved nutrition, longer shelf life, and resistance to harmful pathogens," says Mattoo, who heads the ARS Vegetable Laboratory in Beltsville, Maryland.

Better, Faster, With More Precision

"A traditional breeding approach can require 10 to 15 years to release a new tomato variety. This time can be cut to less than half using biotechnology," says Mattoo. And he has done just that. He has developed several new transgenic tomatoes in almost half the time.

Traditional breeding requires selecting a tomato species that has a desirable trait, such as early ripening, and crossing it with another tomato species that has a good genetic background. The desired result is an earlier ripening tomato that makes it to the market sooner.

Mattoo points out that the goal of a biotechnological approach is no different—the process involved is just more precise.

"In the transgenic approach, we find a particular gene that controls the trait we're interested in, like early ripening or prolonged shelf life," he says. "Then, using molecular tools, we reengineer the gene, confirm it's what we want, and introduce it into a plant so it becomes part of that plant's genome. The plant then possesses the new trait."

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In a greenhouse of the ARS Vegetable Laboratory in Beltsville, Maryland, plant physiologist Autar Mattoo examines tomato plants genetically engineered to enhance phytonutrient content and longevity of the fruit.

Traditional breeding allows transferring hundreds of genes in a relatively random manner. Good or bad traits are sometimes haphazardly passed along to the new plant. With genetically engineered plants, however, scientists know exactly what's going into the plant and what traits will be expressed by the transformed plant.

Tomatoes With Staying Power

If the season is right, you may find a brilliant red tomato sitting on a table in Mattoo's office. The tomato might look like it was just picked, but chances are it's one of his transgenic tomatoes that has been sitting there for weeks.

In collaboration with a Purdue University scientist in West Lafayette, Indiana, Mattoo has developed a novel means for slowing ripening by introducing a gene that controls only this function. He has been perfecting his technique for creating transgenic vegetables for the last 8 years—in Beltsville and West Lafayette.

Mattoo's new transgenic tomatoes have 2.5 times more lycopene than nontransgenic tomatoes. Lycopene is a carotenoid that has strong antioxidant properties. Antioxidants prevent oxygen radicals from causing damage in cells. Carotenoids aid in preventing early blindness in children, preventing cancer, enhancing cardiovascular health, and slowing aging. Not only are the transgenic tomatoes richer in lycopene, they're also more robust and more solid compared to traditional tomatoes.

Another tomato genetically engineered by Mattoo has a longer shelf life. Its cell membranes deteriorate more slowly during and after ripening. "The plants bearing these tomatoes bloom three or four times over the season," he says, "whereas regular tomatoes normally produce just two harvests."

In a plant, thousands of genes control many functions. "Some genes are 'turned on' only at a certain developmental stage or in response to an environmental cue.

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An X-ray film confirms that an engineered gene called *yeast SAMDC*, introduced into the tomato plant, functions only where it is supposed to. The gene is expressed in only the fruit, and not in the stem, leaf, or flower.

Other times they're simply turned off," says Mattoo. "Using genetic manipulation, we can turn these genes on or off at any particular time during growth and development. The genes we introduce into tomatoes are not always switched on. They come on only when engineered to do so, for instance, only when the fruit starts ripening."

Mailing Genes to the Correct Address

Mattoo has a passion and a gift for discovering how plant cells work and for creating easy-to-use methods for improving vegetable production. His latest endeavor is to "mail" the protein product of a beneficial gene to a specific location within a plant cell so that the protein will be more useful for the crop.

In this "ZIP Code" system, as Mattoo refers to it, the gene is constructed so that it carries with it a defined DNA sequence that, when translated by the cell, produces a protein with an added signal defining the protein's destination. This signal guides the new protein to its proper spot in the plant cell.

This ZIP Code system has been shown by other scientists to work like the Post Office ZIP Codes, in that the destination signal is set in place before gene transfer. This method ensures that the product of the new gene will not end up at a place in the cell where it could be damaged. The system can work with many fruits and vegetables.

With the new transgenic foods, Mattoo says the genetic material can be engineered so that it is expressed only under controlled conditions. Each gene is carefully reconstructed to check that all the elements are in place and in sync. No single block is left unchecked.

"Imagine construction of a bridge," says Mattoo. "The engineer has to ensure that all parts are properly placed and aligned. Any single misstep can undo the bridge. Similarly, genes used to produce transgenic crops are vigorously tested and all elements checked."

Strict Safety Precautions Followed

Mattoo's newly modified tomato has some advantages, such as reduced spoilage and increased nutritional and health benefits. But before it can be made available as a food, it will undergo rigorous testing for health and environmental safety.

"The public's confidence in food safety is too important to compromise," says John W. Radin, ARS national program leader in Beltsville, Maryland. "This type of product, however, represents the next generation of genetically engineered foods. It will bring to the consumer's table important benefits that could not have been achieved using traditional breeding."—By **Tara Weaver-Missick,** ARS.

This research is part of Plant Biological and Molecular Processes, an ARS National Program (#301) described on the World Wide Web at http://www.nps.ars.usda.gov/programs/cppvs.htm.

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